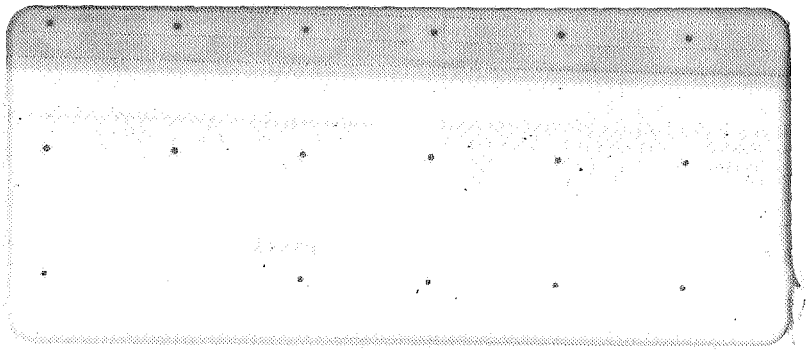

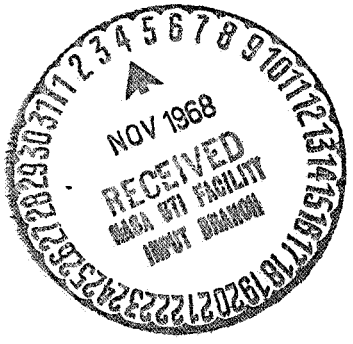

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ENGINEERING PLANNING DOCUMENT

SPACE FLIGHT OPERATIONS

MEMORANDUM

RANGER III

EPD-72

25 MAY 1962

Compiled by:

G. J. Henninger

Approved by:

M. S. Johnson
Space Flight Test Director

J. D. Burke
Project Manager, Ranger Project

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CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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Senior Staff

Burke, J. D.
Clausen, C. M.
Cole, C. W.
Cummings, C. I.
Eimer, M.
Felberg, F.
Giberson, W. E.
Goddard, F. E.
Gunther, F. C.
Haglund, H. H.
Hibbs, A. R.
Howard, W. R.
Huber, B. P.
James, J. N.
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McGarrity, J. W.
Meghreblian, R.
Morris, B. T.
Neiswanger, G.
Pantaz, J. T.
Parks, R. J.
Pickering, W. H.
Rechtin, E.
Robillard, G.
Rose, R. F.
Schurmeier, H. M.
Shafer, J. I.
Sparks, Brian O.
Stewart, H. J.
Wolfe, A. E.

Bartz, D. R.
Bilbo, T. S.
Boyle, M. J. (25)
Briglio, A.
Bronstein, L. M.
Colella, F.
Cotrill, H.
Curtis, H. A.
Dickinson, A. E.
Emmerson, G.
Gates, C. R.
Gerpheide, J.
Gilchriest, C. E.
Goldfine, M.
Guderian, C.
Hamilton, T.
Harker, R. B.
Heacock, R. L.
Henninger, G. J. (5)
Hoover, W.
Jackson, J. G.
Jacobson, N. F.
Jaffe, L. D.
Johnson, M. S.
Kaplan, L. D.
Kehoe, J. J.
Keyser, J. H.
Koukol, J. F.
Landel, R. F.
Laufer, J.
Levoe, C.
Levy, H. (10)
Lunine, L.
Madsen, P. C.
Mallis, R. K.
Margraf, H. J.
McDonald, R. R.
McGee, J. F.
McKee, J. R.
Moore, M. K.
Nalbandian, A. (5)
Ofer, J. T.
Paulson, J. J.
Piasecki, L. R.
Porter, J. C.
Renzetti, N. A.
Richardson, H. A.
Rygh, P. J.
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Schneiderman, D.
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Sweetnam, G. E.
Tardani, P. A.
Thiele, C. L.
Victor, W.
Walenta, I.
Washburn, H. W.
Wheelock, H. J.
Woods, W. R.

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I. INTRODUCTION

A. Purpose

The Space Flight Operations Memorandum summarizes, on the basis of the information available at this time, the following:

1) Performance of the Space Flight Operations Complex (SFOC).

2) Performance of the various tracking facilities involved.

3) Analysis of the telemetry data received.

4) Performance of the spacecraft.

5) Orbital data.

B. Summary

Ranger III was launched on January 26, 1962 at 203011 GMT. A failure in the Atlas ground guidance system resulted in a late booster cutoff with no control over the sustainer cutoff time to compensate for the excess velocity accumulated. Two programmed Agena burning periods followed and the spacecraft was injected into an orbit with too high an energy for it to intercept the Moon. The excess injection energy was considerably greater than that which the mid-course propulsion system was designed to correct, so that the possibility of a successful lunar impact mission was ruled out early in the flight.

The over-all flight performance of the spacecraft was quite successful, but there were a few failures which resulted in some modifications to the RA-4 spacecraft and supporting operations. The stations of the Deep Space Instrumentation Facility (DSIF) provided tracking and telemetry coverage continuously for five days except for periods when the RF signal was too weak to recover. The spacecraft signal was lost at 1854 GMT on January 31, shortly after the supply of gas used for attitude stabilization was exhausted. The spacecraft at loss of signal was approximately 452,000 statute miles from Earth.

II. SPACE FLIGHT OPERATIONS COMPLEX (SFOC)

The Space Flight Operations Complex is the area wherein all decisions relative to the flight are made. The extent to which these decisions are correct and are efficiently made is a measure of the proper functioning of the Complex. The ability to react efficiently to nonstandard modes of operation is also an important measure of the proper functioning of the Complex.

From launch to injection no downrange data were supplied by AMR. Personnel in the Space Flight Operations Center generated the initial DSIF acquisition information using the time of flight and a nominal trajectory. The orbit was determined to the desired level of accuracy at the times required. The non-standard trajectory was recognized early enough so that sufficient evaluation of the alternative missions was possible.

The midcourse maneuver was initiated somewhat earlier than planned. The command was generated, checked, and transmitted to the DSIF with no difficulties or holdups.

The terminal maneuver was initiated much earlier than planned. The SFOC was able to react to the change with no difficulty.

For this flight, the Space Technology Laboratory's IBM 7090 computer was used as a backup to the JPL Central Computing Facility. At no time was it necessary to use this backup capability.

III. TRACKING PARTICIPATORS

A. General

The principal participators in tracking Ranger III were the Atlantic Missile Range (AMR) and the Deep Space Instrumentation Facility (DSIF). A blown fuse caused by the activity of TV cameramen covering the operation resulted in a power failure in the LCTT and the RFT. Standby power was in effect within one minute and both trailers were on firm power within approximately twenty minutes. Tracking participation divides operationally into launch-to-injection and post-injection phases. Participation and performance of each tracking facility and therefore described below under the appropriate phase.

B. Liftoff-to-Injection

1. AMR Participation in Tracking Ranger

a. Up-Range (Antigua) Stations

No radar data of the Agena parking orbit was received either by JPL or the AMR computer (Impact Predictor Building) due to failure of communication equipment at San Salvador, Antigua, and Puerto Rico. No Twin Falls Victory tracking ship participation was expected. The data from only one of these sources, Antigua, was to be relayed to JPL in real time.

b. Down-Range (Ascension, American Mariner Ship) Stations

Due to lack of information from up-range stations and the nonstandard trajectory, the Ascension Island radar did not acquire the Agena until about ten minutes after injection (four minutes after rise at South Africa). The data was received by JPL but was not used because 1) the MTS had already acquired the spacecraft, and 2) range ambiguities were present in the data.

The American Mariner (DAMP) ship acquired the Agena on schedule and obtained data on the early postinjection orbit but, due to communication (atmospheric loss of communication at twilight) and operational difficulties on alternate transmission frequencies, the data did not reach JPL or the Cape facility in real time. Some hours later this data was retransmitted to the Cape Canaveral Impact Predictor Building. The data was not used; however, a copy was supplied to JPL and was subsequently analyzed.

c. Analysis of Ascension and American Mariner Data

The Ascension data was surprising in that the first point received was at a range of 4,738 km. The last data was at a range of 5,489 km. The data began at 4° elevation angle and went down to 2.4°. Fifteen time points (at 6 seconds per sample) were received and were acceptable.

The American Mariner data as received at the Cape began at a range of 798 km and an elevation angle of 17 degrees. The elevation angle steadily decreased to the last point at 5° and 1690 km of range. Eleven of the 33 data (at 3 seconds per sample) were rejected as unacceptable.

An orbit was fitted to all data of each of the data sources above and the resulting data root-mean-square fit (observed minus best fit, no mean or systematic errors subtracted) are given in Table I. Predicted azimuth and elevation angles at 20 hours 56 minutes 11 seconds based on each orbit were used for comparison. Results are shown on Table II.

Table I. Data, RMS Fit

	Range (km)	Azimuth (degrees)	Elevation (degrees)
Ascension	0.00568	0.0254	0.0339
American Mariner	0.00350	0.0201	0.0434

Table II. Resulting Predicted Data from Table III Orbits (at 20 hrs 56 min 11 sec)

	Azimuth (degrees)	Elevation (degrees)
JPL-DSIF	302.876	2.365
Ascension	303.034	2.373
American Mariner	303.410	2.300
Both Ascension and American Mariner data would have given acceptable prediction accuracy.		

The Ascension data had range ambiguities of 1,152,570 yards due to the 142 pulse-per-second pulse repetition rate. The ambiguity was resolved by referring to the JPL orbit to get an estimate of the range; it was resolved as 4 pulses or 4,222,435 km added to the reported range. Note that this data occurred after the Agena retromaneuver; no attempt was made to remove the effects of this impulse to improve comparison with the JPL orbit. The orbits based on JPL-DSIF, Ascension, and American Mariner data are shown in Table III.

Table III. Orbits (True Equator-Equinox of Epoch)

	Semi-Major Axis (a)	Eccentricity (e)	Inclination (degrees)	Right Ascension of Ascending Node (degrees)	Argument of Perigee (degrees)	Degrees (+)	Epoch 1/26/62
JPL-DSIF	-498,760	1.0133382	29.543	247.160	166.461	173.973	20h50m41s
Ascension (Post Retro)	-873,730	1.0075900	29.641	247.337	166.047	173.922	"
American Mariner	-483,390	1.0137635	29.196	247.478	166.373	173.000	"

C. Postinjection

1. General

DSIF participation in the Ranger 3 operation had begun by January 10, 1962. At that time the checkout and preparation of the various station subsystems was in progress. A trailer containing equipment for recording video signals was rented and was located at the Goldstone Tracking Station. Operational readiness tests involving the whole DSIF were conducted on January 16, 19, and 23. On January 24 the DSIF was "in the green" for the Ranger 3 launch.

The DSIF was intended to provide several spacecraft communication capabilities during the Ranger III mission. All DSIF stations (DSIF 1, Mobile Tracking Station; DSIF 2, Goldstone Pioneer Station; DSIF 3, Goldstone Echo Station; DSIF 4, Woomera Tracking Station; DSIF 5, Johannesburg Tracking Station) had the capability of recording telemetered information from the spacecraft on magnetic tape. DSIF Stations 3 and 5 also had equipment for encoding selected telemetry measurements into a teletype format for transmission back to JPL for near-real time analysis. All stations could provide tracking data consisting of time-labelled pointing angles and doppler frequency. Transmitters at DSIF Stations 1 and 3 would allow more accurate tracking data to be obtained when these stations were able to interrogate the spacecraft transponder. The transmitter at DSIF 3 could also allow desired spacecraft actions to be commanded from the ground. The receiver at DSIF 2 was equipped with a Maser amplifier and a Cassegrain reflection system. This equipment provided this station with the most sensitive listening system in the DSIF and was intended for use during the capsule retromaneuver.

2. Launch Phase

Launch of the spacecraft occurred at 2030 on January 26, and the DSIF experienced no difficulty in acquiring and tracking the spacecraft (see Table IV). The spacecraft was initially acquired by DSIF 1 at 2055 and by DSIF 5 at 2056. At these times the spacecraft was radiating through the omniantenna and the received signal strengths at DSIF Stations 1 and 5 were approximately -114 dbm and -104 dbm, respectively. As the spacecraft continued away from Earth the received signal strengths gradually decreased. At 215000 the signal strength at DSIF 1 had decreased to -143 dbm and at this station telemetry data could no longer be recovered from the signal. Shortly before this, at approximately 2127, DSIF 4 acquired and continued tracking until 014230 on January 27 when the spacecraft "set" below the station horizon. During this period the spacecraft signal levels were -146 dbm, -126 dbm, and -131 dbm at DSIF Stations 1, 4, and 5 respectively.

After the initial acquisition, DSIF Stations 1 and 5 continued tracking until approximately 1000 on January 27, or about 1 1/2 hours after acquisition at the Goldstone Stations, DSIF 2 and DSIF 3. DSIF Stations 1 and 5, during their tracking periods, obtained tracking data and telemetry data. These data were used in determining the spacecraft orbit and evaluating the spacecraft performance.

Approximately one-half hour after the spacecraft rose above the Goldstone horizon, while DSIF Stations 1 and 5 were still tracking, a command was transmitted to the spacecraft. This command transmission was successful and

Table IV. DSIF View Periods

DSIF	ACQUISITION (GMT)	LOST (GMT)
1	26/205523	27/095800
5	26/205639	27/095624
4	26/212700	27/014230
3	27/083903	27/183655
4	27/145320	28/025030
5	27/221642	28/102247
1	28/042349	28/104012
3	28/083903	28/175400
4	28/150100	29/025800
5	28/223044	29/101400
3	29/083910	29/190355
4	29/150300	30/025800
5	29/223836	30/101650
3	30/083300	30/190700
4	30/150000	31/025700
5	30/223148	31/101300
2	31/103540	31/185324
3	31/155700	31/185324
4	31/145700	31/230500 1)
5	31/234522	01/093200 1)
4	01/145600 2)	01/230000 2)
5	01/223000 2)	02/100000 2)
2	02/111000 2)	02/120000 2)

1) Searching for spacecraft signal, very little data obtained.

2) Acquisition attempts generally unsuccessful.

caused the spacecraft to switch the transponder signal from the omniantenna to the high-gain antenna. This switchover caused an immediate increase of about 28 db in the received signal strength. This increase in signal strength was sufficient to allow the Mobile Tracking Station once again to record telemetry information.

By the time the spacecraft was acquired at the Goldstone Stations it was apparent the orbit was nonstandard. The spacecraft would not hit the Moon and would not pass close to the Moon during a Goldstone visibility period. This latter occurrence would preclude the possibility of obtaining TV pictures of the lunar surface.

3. Midcourse to Terminal Maneuver Phase

Since the corrective maneuver required to obtain a lunar impact was beyond the capability of the maneuver system, a fly-by maneuver was chosen as the alternative and the necessary commands were generated by the Space Flight Operations Center. These commands would ensure that the spacecraft passed in the vicinity of the Moon during a Goldstone Station visibility period.

After the spacecraft signal was switched to the high-gain antenna, preparation of the spacecraft for the midcourse maneuver began. The three stored commands defining the midcourse maneuver were transmitted at one-minute intervals. The first command was transmitted at 0923 and the last command was transmitted at 0925. Successful reception of these commands was indicated by spacecraft telemetry. Prior to the transmission of the midcourse maneuver initiate command, one final preparatory command transmission was sent. The antenna switchover command was transmitted at 0955 and caused the output of the transponder to be switched from the high-gain (directional) antenna to the omniantenna. This switchover dropped the received signal strength from -110 to -145 dbm but enabled communication to be maintained with the spacecraft while it was engaged in the attitude changes required for the midcourse maneuver.

The midcourse maneuver initiate command was transmitted from the Goldstone Echo Station at 1000 GMT on January 27. Response of the spacecraft was detected immediately by a change in the type of telemetry being transmitted. (During the midcourse maneuver, some of the important telemetered data was different from that telemetered during the cruise portion of the flight.) The Goldstone Stations continued tracking the spacecraft during the maneuver until, at 1015 GMT, the Echo Station receiver lost the signal. Two and one-half minutes later, the Pioneer Station also lost lock. Both stations had reacquired the signal by 1020 GMT, but the signal strengths were so low (-153 dbm at the Echo Station and -160 dbm at the Pioneer Station) that no telemetry data could be recovered. At 1030 GMT the signal strength began increasing and by 1040 GMT all telemetry data was again being recorded. However, by this time, as scheduled in the maneuver sequence, the telemetry transmission mode had cycled to the cruise mode.

After reacquisition, the Goldstone Stations continued tracking with the received signal level of -145 dbm. At 1137, after allowing the spacecraft to reacquire the Sun and Earth (to ensure proper pointing of the high-gain antenna), an antenna switchover command was transmitted to the spacecraft. This raised the signal level to -112 dbm. Shortly after the transmission of this command, the

Pioneer Station conducted a search for the seismometer capsule signal. A signal at the capsule frequency (960.15 mc/s) was detected and the receiver "locked up" on a received signal of -150 dbm. The Pioneer Station listened to the capsule transmission until 1311, when tracking of the transponder signal was resumed.

The DSIF continued its tracking and telemetry recording program. The Woomera Station and then the Johannesburg Station each successively acquired and tracked the spacecraft signal until it "set" below their respective horizons.

Soon after the Johannesburg Station acquired the spacecraft, the Mobile Tracking Station was also requested to track the spacecraft. The Mobile Tracking Station is normally not required to track after its initial view period; however, because a discrepancy was discovered in the postmidcourse doppler data from the Goldstone Echo Station, it was necessary to reactivate the MTS. Aside from the Goldstone Echo Station, the Mobile Tracking Station was the only station which had a transmitter and, therefore, was the only other station capable of providing doppler data of sufficient accuracy to allow an accurate postmaneuver orbit to be determined.

4. Terminal Maneuver Phase

The time of transmission of the terminal maneuver command could not be determined until an accurate postmaneuver orbit could be computed. The Mobile Tracking Station first acquired the spacecraft signal at 042349 GMT, the spacecraft transponder acquired the MTS transmitter, and the tracking system was "locked up" in the two-way mode. The received signal strength held fairly steady at approximately -131 dbm. At 084500 GMT, tracking was interrupted to allow the spacecraft transponder to acquire the Goldstone transmitter. At 084909 GMT, after the Goldstone tracking system was "locked up" in a two-way doppler condition, the Mobile Tracking Station resumed tracking. The transmitter was shut down, however, since the spacecraft was now locked on the Goldstone transmitter signal. At 104012 GMT, the spacecraft "set" below the Mobile Tracking Station horizon and tracking was terminated. After successful two-way acquisition by the Echo Station at 084703 GMT, both Goldstone Stations tracked until lock was lost during the spacecraft terminal maneuver.

Preparation for the terminal maneuver began with the transmission of three required stored commands at approximately one-minute intervals, at 162941 GMT, 163042 GMT, and 163146 GMT. The terminal maneuver initiate command was transmitted from the Echo Station at 172139 GMT. The spacecraft began the terminal maneuver, and received signal strengths held steady at -118 dbm at the Echo Station and -111 dbm at the Pioneer Station. However, at 172821 GMT, the signal strength began decreasing and, by 173204 GMT, both stations had lost lock. Reacquisition attempts were not immediately successful but, by 173918 GMT, both stations had reacquired the signal. The signal strengths, however, had deteriorated and were fluctuating at both stations (-145 to -149 dbm at the Pioneer Station, and -149 to -153 dbm at the Echo Station).

This decrease in signal strength meant that the receiving of TV pictures of the lunar surface was impossible. In an attempt to improve the signal from the spacecraft, several commands were sent from the Echo Station (see Table V) but none had the effect of raising the signal strength. Therefore, at 183620 GMT, the spacecraft telemetry mode was commanded to the cruise mode and

attempts to retrieve any television pictures were terminated at all stations. (The Woomera Station had been tracking the spacecraft since 150100 GMT.) Before the spacecraft passed below the Goldstone horizon at 185200 GMT, a roll override command was sent to the spacecraft. This command was sent at 183750 GMT, disoriented the spacecraft from its terminal maneuver attitude, and increased the signal strength slightly at Woomera.

5. Post-Terminal Maneuver Phase

After the unsuccessful terminal maneuver, the DSIF continued tracking the spacecraft. However, problems soon became apparent in the received signal. During the period following the terminal maneuver at 230100 GMT, while the Woomera and Johannesburg Stations were tracking, the transponder signal disappeared. Momentary signals were heard by the Woomera Station until 232800 GMT. After disappearance of the signal, the stations alternated periods of capsule tracking with periods of searching for the transponder signal. The transponder signal was not acquired again until 053418 GMT, after the spacecraft had "set" below the Woomera horizon.

Table V. Sequence of Commands Transmitted to Improve the Received Signal Strength During Terminal Maneuver

Time	Action Commanded
180517	Switch transponder signal to omniantenna.
181105	Switch transponder signal to high-gain antenna.
181343	Change hinge angle of high-gain antenna.
181700	Switch transponder signal to omniantenna.
182300	Switch transponder signal to high-gain antenna.

After reacquisition, the transponder signal had developed a periodic dropout condition. Every 13 seconds the spacecraft signal would disappear. This condition did not exist when the spacecraft was being tracked in the two-way mode.

Several additional attempts were made to command the spacecraft from Goldstone. On January 29, an attempt was made, using the midcourse maneuver command addresses, to initiate a maneuver by transmitting three stored commands and an initiate command. No response was observed. On the following day, the configuration of the Goldstone Station was modified to allow the transmitted power to be increased from 200 watts to 7 kw. This modification required the replacing of the tracking feed with the transmitting feed. Since auto tracking was no longer possible without the tracking feed, both antennas were positioned

using the coordinate converter computer. Intensive attempts were made to command the spacecraft and culminated in the transmission of 211 commands (alternate roll override and telemetry mode change commands). These command attempts produced no spacecraft action. On the following day, January 31, twenty antenna switch-over commands were transmitted. The modulation frequency was varied for these commands but no response was obtained from the spacecraft. At the conclusion of the tracking period on January 31, the Echo Station ceased participation in the Ranger III operation.

In the interim between tracking periods at the Goldstone stations, the Woomera and Johannesburg Stations continued tracking. Signal strengths were approximately -130 to -140 dbm. During the final tracking period at the Goldstone Echo Station, the condition of the spacecraft signal was deteriorating. The average level was -140 dbm but there was a continual variation of $\pm$20 dbm about this average. The spacecraft signal continued to deteriorate and by the time the Woomera Station acquired on February 1, only momentary "locks" of one-minute duration were possible. At this time the stations began alternately searching, for half-hour periods, for either the seismometer capsule signal or the transponder signal. At this time only momentary locks were being obtained. The Johannesburg and Goldstone Pioneer Stations were then instructed to secure from the operation. The Woomera Station was to continue attempting signal acquisition at weekly intervals and, to this date, has had only minimal success.

IV. TELEMETRY RECOVERY

A. General

The recovery of spacecraft telemetry during the RA-3 flight was generally very successful. Except for periods when the spacecraft signal was seriously degraded by nonstandard spacecraft performance, the telemetry recorded by the DSIF provided complete coverage of the mission for postflight analysis.

B. Engineering

Near-real time engineering telemetry from DSIF 3 and 5 proved adequate during cruise modes, especially in monitoring the acquisitions. However, loss of signal during the midcourse and terminal maneuvers precluded adequate evaluation of spacecraft performance from real time data at those times. Lack of decommutator synchronization for slow rate measurements was a common problem whenever the spacecraft signal was noisy, but this problem was anticipated. The performance of the teletype encoders was quite satisfactory, particularly at Goldstone. A defective puncher at DSIF 5 resulted in a number of bad data samples, but the volume of good data compensated, in reasonable measure, for the shortcomings. Reporting of telemetered event data by the DSIF, in accordance with the SFOP, was quite satisfactory.

C. Scientific

1. Gamma Ray Experiment

Selected portions of the gamma ray spectrometer data covering the period 090000 GMT on 27 January through 180000 GMT on 28 January have been

processed as an analog readout and decoded. They show that the gamma ray spectrometer operated normally with the exception of its level of gain which is somewhat higher than desired. The extension of the boom was observed as a marked reduction in the counting rate. This reduction gives a measure of the primary and secondary gamma rays being counted which are produced in the spacecraft as differentiated from gamma rays having solar and cosmic origin.

The gamma ray data so obtained will make it possible to design further instrumentation which will better distinguish the desired lunar gamma rays from the background radiation consisting of solar and cosmic gamma rays, and gammas produced in the spacecraft.

It is important to note that this was the first gamma ray experiment package that has been flown beyond the radiation belt and has been able to distinguish between gamma rays and charged particles.

2. Vidicon Experiment

Vidicon pictures have been printed from data coming directly from the Goldstone telemetry tapes. These pictures show that the telemetry was commutated and decommutated from the vidicon correctly, that both shutter and erasure cycles were operating properly, and that there were no horizontal or vertical drifts. Additionally, these pictures show that some degree of electronic focus was being realized. In fact, the very important statement can be made that the vidicon and associated circuitry and telemetry back to Earth worked correctly with no detectable malfunction.

It is also of importance to note that the fiducial marks on the front of the face plate are clearly shown. The appearance of these fiducial marks indicates that light was striking the vidicon face and that this light was probably partially collimated light rather than completely diffuse light. It is expected that the processing of these vidicon pictures by the computer will yield additional useful information.

3. Radar Altimeter

The altimeter was turned on at the nominal 64 minutes after start of the terminal maneuver as indicated by Channel B-2-1 and B-2-2 blips and a change in the modulation on Channel V analog during erase periods. No confirmation of its extension was received. A spectrum analysis of the data is being conducted.

4. Capsule

The capsule was not separated from the bus because no altimeter signal triggered it. The capsule transmitter was tracked by DSIF 4 for a period following loss of the transponder signal due to battery depletion on the pass of January 29-30. The records for this period have not yet been analyzed.

5. Temperature Control

Of the six transducers directly indicating structure temperature, two on the Sun sensors and one on the +Y jet vane actuator read within the predicted band. The three on the helium tank, the nitrogen tank, and the temperature control read 4, 16, and 8 degrees, respectively, above the tops of their predicted bands. Of the six transducers indirectly indicating structure temperature, the one on the transponder indicated the structure was 10° above band. Those on the gyro, the booster regulator, the attitude control DC converter, the battery and power switch, and logic circuitry indicated the structure was within the predicted band.

Thus four transducers indicate the structure stabilized slightly above its predicted band and eight indicate it stabilized within its predicted band. As the predicted bands for all measurements were significantly narrower than the limits of tolerance, all twelve fell well within acceptable limits.

Solar panel temperatures were observed to stabilize at approximately 145° F, some 23° F above the maximum predicted. This effect could result from one or all of the following three causes:

a) Solar cells exhibit a higher absorptance of solar energy than was thought possible.

b) Solar cells exhibit a lower emittance of infrared energy than was thought possible.

c) The black paint used on the back structure of the panels exhibits a lower emittance than was thought possible.

It will probably not be possible to determine which of these effects is applicable since very accurate data is needed during the spacecraft pass through the Earth's shadow for any such calculation to be meaningful.

The gamma ray spectrometer temperature indicated a gradual climb during the entire portion of the flight before midcourse maneuver, going significantly off scale and over 40 cycles above the upper limit of its calibration. Although extrapolations of this magnitude are open to serious question, the data are undergoing detailed analysis. As present it is not possible to explain this phenomenon with any reasonable set of parameters.

6. Extensions and Pyrotechnics

The following extensions were noted at the correct times:

a) Solar panels

b) Gamma ray boom

c) Omniantenna

No verification of the radar altimeter extension was obtained although the event channel was in lock at the time.

All squib firing event pulses were recovered except the one for midcourse motor ignition. The only abnormalities associated with any of these were the transmitter failure at the time the solar panels were extended, and the lack of confirmation of altimeter extension. There is no data telemetered which would give any indication of what happened to the altimeter.

V. SPACECRAFT PERFORMANCE

The spacecraft performance can be divided into three distinct phases: launch, midcourse, and terminal. The launch phase was initiated by starting the launch counter in the spacecraft central computer and sequencer (CC&S) at two minutes before liftoff. The midcourse and terminal phases were initiated by real time ground commands at times selected to optimize the ensuing maneuver sequences under abnormal trajectory conditions. Each phase consisted of a fixed sequence of events to be executed on command from the CC&S. The only variables within these sequences were the duration of the midcourse and terminal maneuver turns, the direction or polarity of each turn, and the velocity increment to be provided by the midcourse motor. These variables were read into the CC&S register as sets of three stored commands from the ground prior to initiating the midcourse and terminal maneuvers.

The spacecraft transmitter was switched back and forth by ground command to transmit over the low-gain (omnidirectional) antenna or the high-gain (directional) antenna. The spacecraft transmitter was on low-gain antenna until first Goldstone acquisition and during the midcourse maneuver. It was twice commanded over during the vidicon period without improving the received signal.

Other ground commands were available to compensate for nonstandard performance. The first of these, hinge override, was attempted when the signal was lost during the terminal maneuver. The spacecraft data encoder was switched by ground command out of scientific mode back to engineering cruise mode after 50 minutes of vidicon data. Other commands were also tested.

A. Launch Phase

The following functions were successfully performed during the launch phase:

1) Capsule transmitter turned on and squib firing assembly armed by inertial switches during the boost phase.

2) Transmitter power increased after separation.

3) Solar panels extended accompanied by sharp degradation in low-gain antenna drive. For further data, refer to interoffice memorandum dated March 19, 1962 to A. E. Wolfe from Lloyd Derr.

4) Sun acquisition (pitch and yaw stabilization, switch to solar panel power).

5) Earth acquisition (locks high-gain antenna on Earth).

6) Gamma ray spectrometer turned on (followed by an abnormal increase in temperature of the instrument).

B. Midcourse Phase

Recovery of spacecraft telemetry during the latter part of the midcourse maneuver pitch turn, the motor firing, and start of Sun reacquisition was seriously hindered because the spacecraft was commanded to an orientation that violated the omniantenna constraint. This was a calculated risk decided upon during the operation and was complicated by the following factors:

1) The spacecraft turned in the opposite direction from that predicted. For further information regarding the command polarity reversal, refer to 1) interoffice memorandum from J. F. McGee to H. M. Schurmeier dated February 5, 1962; 2) Failure Report for DSIF and Telecommunications, Reorder No. 62-55; 3) RA-3 Preliminary Flight Performance Report by A. E. Dickinson, Reorder No. 62-30.

2) The transmitted signal from the low-gain antenna was abnormally low.

3) The receiver at DSIF 2, the more sensitive of the two Goldstone receivers, apparently had a malfunction during this period.

However, sufficient telemetry was recovered to indicate that the CC&S successfully commanded the following functions:

1) Telemetry to midcourse mode.

2) Start and stop commanded roll turn.

   a) Switch in midcourse guidance system; extend high-gain antenna.

3) Start and stop commanded pitch turn.

4) Ignite midcourse motor and shutoff on commanded accelerometer signal (possibly accompanied by a temperature bridge malfunction).

5) Switch out midcourse guidance system.

   a) Telemetry to cruise mode.

   b) Sun reacquisition.

6) Earth reacquisition.

7) Gamma ray boom extension.

C. Terminal Phase

The CC&S successfully commanded the following functions during the terminal maneuver sequence:

1) Break solar lock.

   a) Start vidicon warmup.

   b) Start and stop first commanded pitch turn.

2) Start and stop commanded yaw turn.

3) Start and stop commanded second pitch turn.

   a) Telemetry to scientific mode.

   b) Start vidicon pulse train.

4) Uncover vidicon lens.

   a) Deploy altimeter (no verification of its extension was obtained).

5) Deploy low-gain antenna.

6) Turn on altimeter.

   a) Commutate scientific data.

An extraneous pitch turn command occurred a few seconds after the first commanded turn ended and continued until the commanded yaw turn ended. The high-gain antenna tracked the Earth as the spacecraft continued pitching until the Earth sensor shield blocked off the Earth. When the Earth sensor mounted along the antenna axis lost the Earth's light, a roll search was started and the high-gain antenna beam moved away from the Earth. During the commanded yaw turn, while still pitching and rolling, the antenna apparently locked on the Moon. The precise spacecraft orientation during and after this period is still being investigated.

TABLE VI. SPACECRAFT LAUNCH TO MIDCOURSE MANEUVER EVENTS

EVENT	NOMINAL TIME	ACTUAL TIME L=203011 GMT 1/26/62
START CENTRAL COMPUTER AND SEQUENCE TIMER	L-2 MIN	A=202802 = L-2 MIN 09 SEC.
ARM SQUIB FIRING CIRCUIT	L+2.1 MIN (EST.)	EVENT VERIFIED, NO TIME
CAPSULE TRANSMITTER TURNED ON	L+22 MIN (EST.)	" " " "
AGENA/SPACECRAFT SEPARATION	I+2 MIN 37 SEC.	205247 = I+2 MIN 38 SEC (EST.)
INCREASE TRANSMITTER POWER (1)	A+25 MIN 00 SEC	EVENT VERIFIED, NO TIME
COMMAND SOLAR PANEL EXTENSION (2)	A+33 MIN 00 SEC	210102 =A+33 MIN 00 SEC. (APPROX.)
SOLAR PANELS SQUIBS FIRED	A+ " " " "	" " " " " "
SOLAR PANELS EXTENDED	COMMAND (2) +2 MIN (MAX)	(LESS THAN 2 MIN 18 SEC)
COMMAND SUN ACQUISITION (3)	A+36 MIN 00 SEC.	210402 =A+35 MIN 00 SEC.
SUN ACQUISITION COMPLETE	COMMAND (3) +30 MIN (MAX)	(7.3 MIN)
COMMAND EARTH ACQUISITION (4)	A+3 HR 33 MIN 00 SEC.	1/27 000102 = A+3 HR 33 MIN 00 SEC.
EARTH ACQUISITION COMPLETE	COMMAND (4) +30 MIN (MAX)	(6.8 MIN)
START GAMMA RAY SPECTROMETER EXPERIMENT (5)	A+4 HR 03 MIN 00 SEC.	003102 = A+4 HR 03 MIN 00 SEC
( ) = CC & S COMMANDS		

TABLE VII. SPACECRAFT MIDCOURSE MANEUVER EVENTS

EVENT	NOMINAL TIME	ACTUAL TIME
	1/27/62	1/27/62
TRANSMITTER SWITCHED FROM OMNI TO HI GAIN ANTENNA	GOLDSTONE ACQUISITION	091500 GMT
TRANSMIT MID-COURSE MANEUVER STORED COMMANDS	M-1 HR	
RTC 0 CLEAR COMMAND		092100, 092200
SC-1 ROLL DURATION (6)		092302
CAPACITOR CYCLING PULSE (6)	SC-1 + 5 SEC	092307
SC-2 PITCH DURATION		092400
SC-3 VELOCITY INCREMENT		092504
COMMANDS VERIFIED BY S/C		
SC-1 ROLL DURATION		092321
SC-2 PITCH DURATION		092419
SC-3 VELOCITY INCREMENT		092524
COMMAND SWITCHOVER FROM HI GAIN TO OMNI ANTENNA		
RTC 3 ANTENNA SWITCHOVER	M-5 MIN	095500

( ) = CC&S COMMANDS
TIME IS GMT

TABLE VII. SPACECRAFT MIDCOURSE MANEUVER EVENTS (CONT'D)

EVENT	NOMINAL TIME M = TIME MIDCOURSE MANEUVER INITIATED BY CC&C	ACTUAL TIME
TRANSMIT MID-COURSE MANEUVER START COMMANDS RTC 4 START MANEUVER	M - 23 SEC	100000 = M - 43 SEC
TELEMETRY MODE TO MODE II START ROLL TURN (7)	M	100043 ≡ M
STOP ROLL TURN	M+51 SEC	100137 = M + 54 SEC
START PITCH TURN	M+9MIN 30 SEC	101010 = M + 9MIN 27 SEC
STOP PITCH TURN (10)	M+18MIN 53 SEC	NO TIME
MID-COURSE MOTOR IGNITION (11)	M+26MIN 30SEC	EVENT VERIFIED NO TIME
MID-COURSE MOTOR SHUTOFF (12)	M+27MIN 24SEC	" " " "
TELEMETRY MODE TO MODE III (13)	M+28 MIN	PRIOR TO 102900 M+28 MIN (APPROX)

( ) = CC&S COMMANDS
TIME IS GMT

TABLE VII. SPACECRAFT MIDCOURSE MANEUVER EVENTS (CONT'D)

EVENT	NOMINAL TIME	ACTUAL TIME
START SUN RE-ACQUISITION (13) SEQUENCE	M + 28 MIN	PRIOR TO 102900 = M+28 MIN (APPROX)
SUN ACQUISITION ACHIEVED	COMMAND (13) + 30 MIN (MAX)	(10 MIN)
START EARTH REACQUISITION (14) SEQUENCE	M+ 58 MIN	105839 = M+57 MIN 56 SEC
EARTH ACQUISITION COMPLETE	COMMAND (14) + 30 MIN (MAX)	(23 MIN 10 SEC)
TRANSMIT RTC-3 TO COMMAND SWITCH OVER FROM OMNI TO HI GAIN ANTENNA	M+88 MIN	113700
EXTENDED GAMMA RAY BOOM (15)	M+ 150 MIN	123043 = M+150 MIN 00 SEC

( ) = CC&S COMMANDS
TIME IS GMT

TABLE VIII. SPACECRAFT TERMINAL MANEUVER EVENTS

EVENT	NOMINAL TIME	ACTUAL TIME
C = TIME TERMINAL MANEUVER INITIATED BY CC & S	1/28/62	1/28/62
TRANSMIT TERMINAL MANEUVER STORED COMMANDS	C-1 HR	
RTC 0 CLEAR COMMAND		162700, 162800
SC 4 FIRST PITCH DURATION		162903
SC 5 YAW DURATION		163007
SC 6 SECOND PITCH DURATION		163105
COMMANDS VERIFIED BY S/C		
SC 4 FIRST PITCH DURATION (16)		162944
SC 5 YAW DURATION		163048
SC 6 SECOND PITCH DURATION		163146
TRANSMIT TERMINAL MANEUVER EXECUTE COMMAND RTC-6	C-23 SEC	172200 = C-26 SEC
START PITCH TURN (17)	C	172226
STOP PITCH TURN (18)	C+13 SEC	172239 = C+13 SEC
EXTRANEOUS COMMAND BLIP		172303 = C+37 SEC
START YAW TURN (19)	C+9 MIN 30 SEC	1723136 = C+9 MIN 10 SEC
STOP YAW TURN (20)	C+12 MIN 49 SEC	173454 = C+12 MIN 28 SEC

TABLE VIII. SPACECRAFT TERMINAL MANEUVER EVENTS (CONT'D)

EVENT	NOMINAL TIME	ACTUAL TIME
START PITCH TURN (21)	C+21 MIN 30SEC	174349 = C+21 MIN 23 SEC
STOP PITCH TURN		
TELEMETRY MODE TO MODE IV (22)	C+23 MIN 37 SEC	174517 = C+22 MIN 51 SEC
START VIDICON AND GAMMA RAY PULSE TRAIN		
REMOVE VIDICON LENS COVER	COMMAND (22) + 2 MIN	
DEPLOY RADIO ALTIMETER		
RADIO ALTIMETER DEPLOYED	10 SEC MAX	NOT VERIFIED
DEPLOY LOW GAIN ANTENNA		
LOW GAIN ANTENNA DELOYED	1 MIN MAX	174840 (48 SEC)
TURN ON RADIO ALTIMETER	C+64 MIN 00 SEC	182620 = C+63 MIN 54 SEC
ALTIMETER ON		182620 = C+63 MIN 54 SEC
RTC 5 TELEMETRY MODE I		

( )=CC&S COMMANDS
TIME IS GMT

TABLE IX. SPACECRAFT POST LUNAR & ENCOUNTER PHASE EVENTS

EVENT	NOMINAL TIME	ACTUAL TIME
	1/28/62	
RTC 5 TELEMETRY MODE I		183443
RTC 1 ROLL OVERRIDE		183834
REACQUIRED EARTH		NO TIME
MAIN BATTERY EXHAUSTED		NO TIME
SOLAR POWER REACQUIRED		NO TIME
	1/29/62	
RTC 4 TRANSMITTED TELEMETRY MODE II		1849 (ESTIMATED)
	1/30/62	
NO SUCCESSFUL COMMANDS		
	1/31/62	
RTC 5 TELEMETRY MODE III		1115 (APPROX.)
ATTITUDE CONTROL GAS EXHAUSTED		1230 (APPROX.)
LOST SPACECRAFT SIGNAL		185345
TIME IS GMT		

VI. ESTIMATION OF THE ORBIT

The premidcourse and postmidcourse orbits were determined using the JPL Orbit Determination Program (ODP). The orbital parameters and trajectory characteristics of these orbits are tabulated in Table XI for selected trajectory epochs.

Figure 1 shows the heliocentric orbits of the Earth and probe during the year January 27, 1962 to January 26, 1963.

The legend applying to Table XI follows.

X, Y, Z	Vernal equinox cartesian coordinates in a geocentric equatorial system. The origin is the center of the Central Body. The principal direction ($\vec{X}$) is the vernal equinox direction of date and the principal plane (XY) is the equatorial plane of date. $\vec{Z}$ is along the direction of the Earth's spin axis of date (Kilometers).
$\dot{X}$, $\dot{Y}$, $\dot{Z}$	First time derivatives of X, Y, and Z, respectively, i.e., cartesian components of the probe space-fixed velocity vector (Kilometers/Second).

For Earth as Central Body

R	Probe radius distance (Kilometers).
φ	Probe geocentric latitude (Degrees).
θ	Probe east longitude (Degrees).
v	Probe Earth-fixed velocity (Kilometers/Second).
γ	Pitch angle of the probe Earth-fixed velocity vector with respect to the local horizontal (Degrees).
σ	Azimuth angle of the probe Earth-fixed velocity vector measured east of true north (Degrees).

For Moon as Central Body

R	Probe radius distance (Kilometers).
ϕ	Probe selenocentric latitude (Degrees).
θ	Probe selenocentric east longitude (Degrees).
v	Probe selenocentric-fixed velocity (Kilometers/Second).
γ	Pitch angle of the probe selenocentric-fixed velocity vector with respect to the local horizontal (Degrees).
σ	Azimuth angle of the probe selenocentric-fixed velocity vector measured east of the Moon's mean spin axis (Degrees).

For Sun as Central Body

R	Sun-Probe radius distance (Kilometers).
ϕ	Probe celestial declination (Degrees).
θ	Probe celestial right ascension (Degrees).
V	Probe space-fixed velocity (Kilometers/Second).
γ	Pitch angle of the probe space-fixed velocity vector with respect to the local horizontal (Degrees).
σ	Azimuth angle of the probe space-fixed velocity vector measured east of true north (Degrees).

a	Semi-major axis (Kilometers).
e	Eccentricity.
i	Inclination of the orbit plane to the equatorial plane (Degrees).
Ω	Longitude of the ascending node (Degrees).
ω	Argument of pericenter (Degrees).
ν	True anomaly (Degrees).

Period is measured in days, apogee and perigee in kilometers.

TABLE XI. ORBITAL PARAMETERS OF RANGER III

TIME OF EVENT	EPOCH		CENTRAL BODY				EPOCH OF PERICENTER PASSAGE			PERIOD APOGEE PERIGEE
	X R	Y ϕ	Z θ	$\dot{X}$ v	$\dot{Y}$ γ	$\dot{Z}$ σ	a e	i Ω	ω ν	
PREMIDCOURSE ORBIT	1-26-62 20h 50m 9sec		EARTH				1-26-62 20h 49m 21.311sec			N.A.
	3394.2596	5710.8051	514.39773	-7.7937433	5.6169558	-5.3058356	-496872.40	29.536535	166.48433	N.A.
	6663.2497	4.4275950	341.07499	10.554972	2.3583422	120.51785	1.0133895	247.12882	4.5062035	6652.8823
POSTMIDCOURSE ORBIT	1-27-62 10h 28m 6sec		EARTH				1-26-62 20h 44m 15.361sec			N.A.
T≈0	-129810.64	-82358.524	-49534.951	-1.6952623	-1.5457438	-.52111923	-665413.25	31.499879	168.32439	N.A.
	161516.06	-17.859714	289.14620	11.059184	12.059116	271.04356	1.0096134	244.11586	155.73367	6396.8686
CLOSEST APPROACH TO MOON	1-28-62 23h 48m 6sec		EARTH							
E	-307437.86	-253162.85	-99317.744	-1.1616432	-1.0991928	-.23706543				
	410455.20	-14.002826	94.689983	28.976260	3.1760772	270.30900				
			MOON				1-28-62 23h 25m 10.284sec			N.A.
M	-370.37938	-13268.310	-34505.641	-1.8239202	-.42028658	.046703355	-1512.3978	110.37414	271.37346	N.A.
	36970.589	-44.322897	222.82757	1.9403007	3.7090770	284.10317	25.387862	193.50713	3.9952835	36884.147
T≈10 DAYS	2-6-62 10h 28m 6sec		EARTH							
E	-915674.49	-852358.43	-173863.07	-.70221030	-.68850393	-.066504146				
	1263013.4	-7.9123104	289.84556	91.203401	.61748666	270.04364				
			SUN				1-23-62 9h 8m 19.734sec			406.46288
S	-.10911166E9	.91171155E8	.39729169E8	-21.446504	-20.840285	-8.8033893	.16064861E9	23.201545	122.17778	.17403645E9
	.14763448E9	15.611012	140.11865	31.173220	1.1240084	107.38299	.083336125	.80131479	14.738580	.14726079E9
T≈100 DAYS	5-7-62 10h 28m 6sec		EARTH							
E	-9319692.0	-3376749.0	-520193.00	-2.2709510	-.79943180	-.38278580				
	9926212.6	-3.0040153	178.10587	722.86227	.19214944	269.97969				
			SUN				1-18-62 17h 16m 53.875sec			394.95590
S	-.11345464E9	-.10366836E9	-.44008182E8	18.822994	-19.748772	-8.6003590	.15760215E9	23.287572	117.78936	.16785648E9
	.15986183E9	-15.979229	222.41928	28.605686	3.6391008	107.16686	.06506468	.71381237	106.34340	.14734782E9

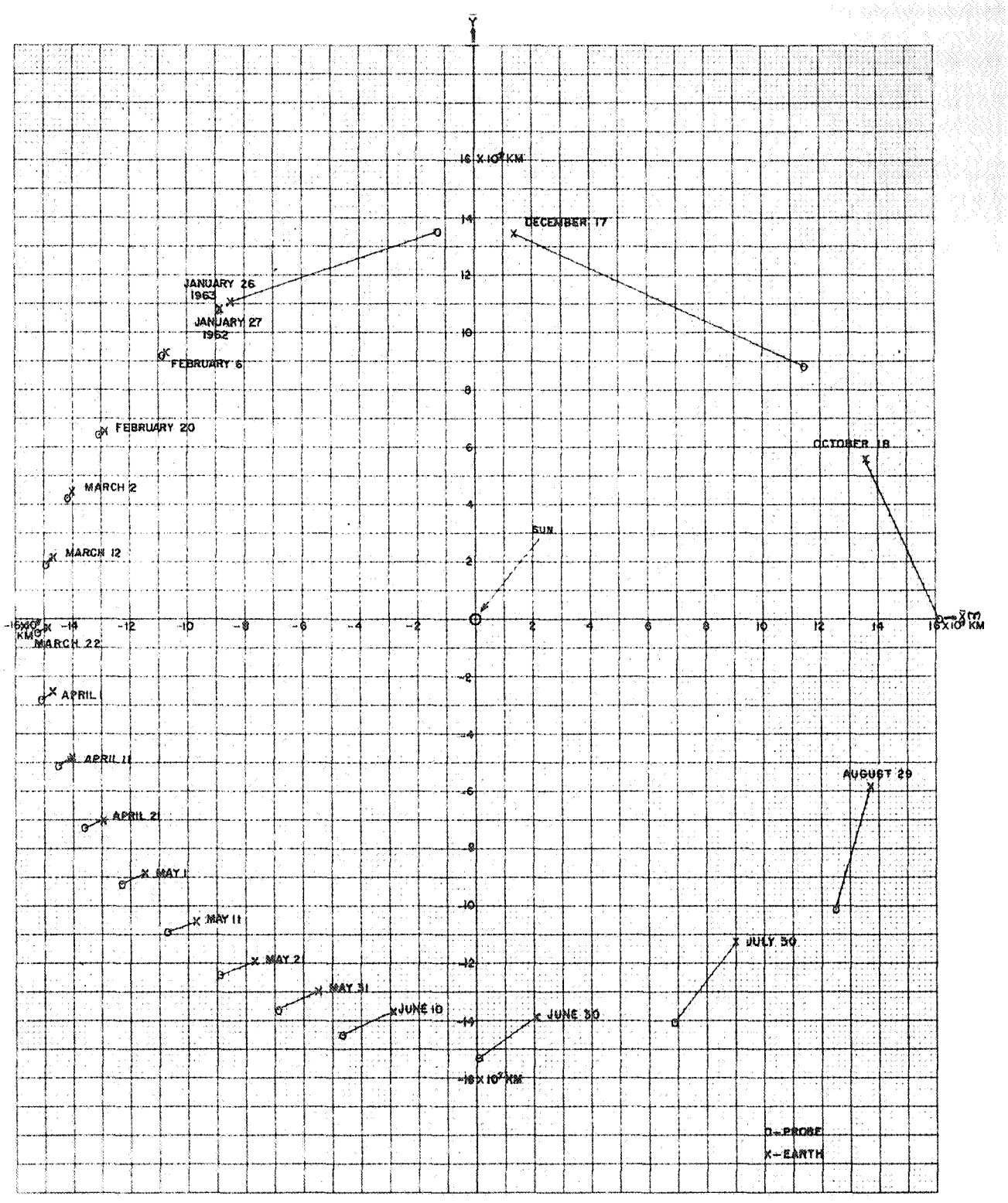

Figure 1. Heliocentric Orbits of the Earth and Probe for the Year Ending January 26, 1963 Projected in the Equatorial Plane